REMARKS

Claims 1-17 are pending in this application.

Applicant respectfully requests reconsideration of the rejection of claims 1-17 under 35 U.S.C. § 102(b) as being anticipated by *Giewont et al.* (U.S. Patent No. 6,388,327). As will be explained in more detail below, the *Giewont et al.* reference does not disclose nor suggest each and every feature of the methods defined in independent claims 1, 7, and 13.

Applicant has amended each of independent claims 1, 7, and 13 to specify that the first thermal process includes diffusing nitrogen in the TiN_x layer into the layer of cobalt salicide and that the Ti diffusion from the TiNx layer is less than the prior art. As discussed in Applicant's specification, the benefit of diffusing nitrogen from the TiN_x capping layer through the cobalt layer and into the cobalt salicide layer is that the nitrogen atoms prevent the cobalt salicide grains from collecting and thereby forming larger grains during initial and subsequent thermal processing (see Paragraph 26). Larger grains of cobalt salicide do not connect together within the cobalt salicide layer, and such large, unconnected grains cause poor conductivity in conventionally formed cobalt salicide layers.

The *Giewont et al.* reference discloses a process for placing a capping layer over a silicide-forming metal and has a composition such that nitrogen diffusion therefrom is insufficient to cause formation of an oxynitride from an oxide layer on the underlying silicon. The capping layer may be a metal layer from which no N diffusion occurs, or one or more layers including Ti and/or TiN arranged so that N atoms do not reach the oxide layer. A method is also described for forming the Ti and TiN layers. It is advantageous to deposit a non-stoichiometric TiN layer that is deficient in N, by sputtering from a Ti target in a nitrogen flow insufficient to cause formation of a nitride on the target.

The *Giewont et al.* reference teaches that the "conventional TiN layer" ... "is generally not truly stoichiometric, but includes ***additional*** nitrogen. Nitrogen atoms may thus diffuse

out of the capping layer 3 into and through the cobalt layer 2." (Col 2, ln 28-32, emphasis added)

Further, the *Giewont et al.* reference teaches that the additional nitrogen atoms in the non-stoichiometric TiN layer diffuse out of the capping layer and cause an undesirable oxynitride layer to form. (Col 2, ln 28-47)

The *Giewont et al.* reference also teaches how to use less than stoichiometric TiN (N-deficient) (col 4, ln 55- Col 5, ln 4) but only in combination with a nitrogen rich non-stoichiometric layer. (Col 5, ln 5-10)

In summary, the *Giewont et al.* reference does not teach or even suggest how to use an actually stochiometrically balanced TiN layer to improve thermal stability and still reduce the grain size of the cobalt salicide while also reducing or minimizing the undesireable diffusion of Titanium atoms into the underlying silicon layer and thereby form excess amounts of $TiSi_x$ as both the thermal stability and resistance of $TiSi_x$ are poor. (Applicant's specification at paragraph 22)

Stoichiometry is the quantitative relationship between constituents in a chemical substance. A stoichiometric material means that the quantitative relationship between constituents in a chemical substance are balanced. In the case of TiN, a stoichiometrically balanced TiN layer would have one Nitrogen atom for every Titanium atom because each Titanium atom bonds with a single Nitrogen atom. Therefore, the chemical formula for a stoichiometrically balanced TiN layer would be TiN.

However, the *Giewont et al.* reference discloses a TiN layer that is non-stoichiometric. Further, the *Giewont et al.* reference describes the non-stoichiometric TiN layer as being nitrogen deficient and therefore having *less* than one nitrogen atom for each titanium atom.

The *Giewont et al.* reference does not define a precise non-stoichiometric TiN proportion of nitrogen to titanium but only states that the non-stoichiometric TiN proportion

is *nitrogen deficient*. The *Giewont et al.* reference further defines two different non-stoichiometric TiN layers where one nitrogen deficient non-stoichiometric TiN layer is more nitrogen deficient than the other nitrogen deficient non-stoichiometric TiN layer. (Col. 4, Lines 54-67 and Col. 5, Lines 1-10)

No where does the *Giewont et al.* reference teach or suggest that the TiN layer is at least stoichiometrically balanced. More specifically, no where does the *Giewont et al.* reference teach or suggest purposefully forming a "TiN_x layer includes x atoms of nitrogen for each atom of titanium in a TiN_x molecule, and a value of x is greater than 0.9…"

Therefore, the *Giewont et al.* reference does not teach nor even suggest that the "capping layer includes additional nitrogen, nitrogen will diffuse into and through the cobalt layer 2 during the first anneal" and the Examiner has misunderstood or misinterpreted the teachings of the *Giewont et al.* reference.

In view of the foregoing, Applicant submits that the *Giewont et al.* reference does not disclose each and every feature of the methods defined in independent claims 1, 7, and 13. Accordingly, claims 1, 7, and 13 are patentable under 35 U.S.C. § 102(b) over *Giewont et al.* Claims 2-6, each of which ultimately depends from claim 1, claims 8-12, each of which ultimately depends from claim 7, and claims 14-17, each of which ultimately depends from claim 13, are likewise patentable under 35 U.S.C. § 102(b) over *Giewont et al.* for at least the same reasons set forth above regarding the applicable independent claim.

Applicant respectfully requests reconsideration of the rejection of claims 1-17 under 35 U.S.C. § 103(a) as being unpatentable over the *Giewont et al.* reference. As described above the *Giewont et al.* does not raise a *prima facie* case of obviousness against the methods defined in independent claims 1, 7, and 13.

It is axiomatic that an obviousness rejection based on combination of references is proper only if the prior art would have suggested to one having ordinary skill in the art the desirability of combining the references in the proposed manner. As stated above, the TiN layer taught by *Giewont et al.* is *nitrogen deficient* and that any *nitrogen rich layer* should be avoided by providing that "less N is available to diffuse into and through the cobalt layer 2. Accordingly, formation of an oxynitride is avoided." (Column 5 lines 41-44).

Further, at column 2, lines 33-38, the *Giewont et al.* reference states "[a]lthough possible beneficial effects of introducing nitrogen into a self-aligned $CoSi_2$ are known (for example, improving thermal stability to agglomeration), *the involvement of nitrogen in the cobalt silicide formation process has an undesirable effect"* (emphasis added). As explained in the *Giewont et al.* reference, the diffusion of nitrogen atoms causes an undesirable oxynitride layer to form between the cobalt layer and the underlying layer of silicon (or layer of native oxide formed on the silicon) (see column 2, lines 38-41). This oxynitride layer is undesirable because it blocks the diffusion of silicon atoms into the cobalt layer, and thereby results in the incomplete formation of cobalt silicide. Therefore the *Giewont et al.* reference seeks to minimize the nitrogen in the nitrogen deficient non-stoichiometric TiN layer.

Further, the *Giewont et al.* reference does not teach that the 3:1 ratio of nitrogen gas to argon gas will result in the formation of a film that has *excess* nitrogen. Rather, no where does the *Giewont et al.* reference actually teaches the 3:1 ratio of nitrogen gas to argon gas will result in the formation of a film that has *excess* nitrogen.

In light of the strong teaching in the *Giewont et al.* reference regarding the undesirable effect of introducing nitrogen into a cobalt silicide formation process, Applicant respectfully submits that the *Giewont et al.* reference would have guided one having ordinary skill in the art to avoid the diffusion of nitrogen into and through the cobalt layer. As such, the *Giewont*

et al. does not raise a *prima facie* case of obviousness against the methods defined in independent claims 1, 7, and 13, as amended herein.

Accordingly, for at least the foregoing reasons, independent claims 1, 7, and 13, as amended herein, are patentable under 35 U.S.C. § 103(a) over the *Giewont et al.* reference. Claims 2-6, each of which ultimately depends from claim 1, claims 8-12, each of which ultimately depends from claim 7, and claims 14-17, each of which ultimately depends from claim 13, are likewise patentable under 35 U.S.C. § 103(a) over the *Giewont et al.* reference for at least the same reasons set forth above regarding the applicable independent claim.

In view of the foregoing, Applicant respectfully requests reconsideration and reexamination of claims 1-17, as amended herein, and submits that these claims are in condition for allowance. Accordingly, a notice of allowance is respectfully requested. In the event a telephone conversation would expedite the prosecution of this application, the Examiner may reach the undersigned at **(408) 749-6923**. If any additional fees are due in connection with the filing of this paper, then the Commissioner is authorized to charge such fees to Deposit Account No. 50-0805 (Order No. MXICP012).

Respectfully submitted,
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